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PRINCIPAL INVESTIGATOR: Patricia Hastings

CONTRACTING ORGANIZATION: Tripler Army Medical Center
Tripler AMC, Hawaii 96859-5000

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6. AUTHOR(S)
Patricia Hastings

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Tripler Army Medical Center
Tripler AMC, Hawaii 96859-5000

E-Mail:

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Final Report

Low Band Telemedicine Decision Support System for Disaster Situations
Proposal Number: 1999000221

Patricia Ruth Hastings DO, FACEP

Abstract

Problems

Problems 1) Poor quality of commercial wireless Internet connectivity We frequently faced poor Internet connection with a commercial wireless Internet service provider, which frustrated users. This is anticipated to improve as service improves regionally and globally. 2) Little evidence for clinical decision making We decided to develop a decision support system for crush injury because little epidemiological study is available for other disaster unique medical diagnoses. 3) Narrow clinical application Considering the clinical application of such decision support systems, more benefit will be provided by decision support tools for more common diseases and injuries. Future direction 1) Improve connectivity A more stable network connection is required for clinical use of the system. Stand-alone applications that can store the data in a handheld device are necessary to develop. 2) Security and confidentiality Security and confidentiality such as encryption, IP filtering and authentification, should be considered. These issues are for the HIPAA (Health Insurance Portability and Accountability Act) regulation. 3) Wider clinical application Decision support systems (DSS) that will cover much wider clinical applications will be beneficial. Clinical DSS for further predictive model development is planned. 4) User interface Development of optimal user interface for the decision support system with users is necessary.

Deliverables

1) Predictive model development We developed a predictive model for patients with crush injury using existing dataset from the Hanshin-Awaji Earthquake. We studied 12 possible predictive factors, which is available at the field examination: age and gender, respiratory rate, systolic blood pressure, pulse rate and availability of urine specimen

with evaluation of urine color / rescue time: hours from earthquake impact to patient extrication and time from extrication to initial patient examination, volume of intravenous fluid during the first three days following the earthquake, and Injured anatomic sites. A logistic regression model was used to build a predictive model to estimate deleterious outcomes defined as hemodialysis and/or death (severe and fatal crush syndrome). Total of 330 patients data were split into two parts: training data set (220 cases) and test data set (110). The training data set was used to construct logistic regression model and the test data set was used to test a validity of the model. The three prognostic factors, odds ratio and 95% confidence intervals in the final logistic regression model are listed in table 1. 2) Web-based database system development Figure 1 shows a structure of the web-based database system. Oracle 8i application program has been used to develop the web-based database system. As the illustration shows, a table in a relational database is organized in rows and columns. Each column, called a field, represents a specific type of data stored in the table. For example, in the PATIENT table, columns include the patient's ID, last name, and sex. Each row called a record represents a set of related data about a single entity, such as a person. Many rows make up a table. For example, each row in the PATIENT table represents a patient's demographic information. The patient ID identifies each patient or contact in the PATIENT table. The ID is used as a key in many tables, which means that this ID is used to refer any information belong to each patient (e.g. age, gender) from other tables. Since each patient might have several data entry points, ID in the OBS table named as OBSID, is used as unique identifier for the each record stored in the database system. This OBSID is used to identify each record stored in the database, which is automatically generated. Care providers, however, are not required to input the OBSID to retrieve the stored data. They can input patient ID, first name, or last name to identify the patient. Then, the database system would return a list of possible patients, so that care providers can identify the patient. ID and password is required to access any data stored in the database system. 3) Decision support system development Specification for the decision support system Server: IRIX64 Operating system: IRIX 6.5 version Network: Internet Language: Java

Software on server JDK: 1.3 version Apache Jakarta- Tomcat: 3x version JDBC driver: 1.2 version

Client Browser: PC: IE /Netscape browser Handheld: Palmscape

Handheld Hardware: Palm Vx and Visor Prism Operating system: Palm OS 3.5 version

Network: commercial wireless ISP (Omnisky Inc.) A JSP (Java Servlet Page) program running on a server creates web pages, which can be accessed by Web browser or Palm browser. The program interacts with the user, gets patient's demographic data directly from database and then collects and inserts the patient's observation data into the database. The system calculates the possibility of Crush Injury Syndrome and provides a suggestion of how to handle the patient. Decision support system for handheld In the initial screen of the decision support system, care providers must input their user ID and password in order to enter the decision support system. In the next step, care providers are asked to input patient demographics information. The web-based database system automatically generates a patient ID. Care providers can put the ID on the triage tag for future information retrieval (Figure 2). Then, care providers are asked to input important physiologic information of the patient including vital signs and important predictive factors (Figure 3). All the data input here is stored in the database for future retrieval. After submitting these data, the server computer calculates a possibility of

deleterious outcomes based on the data input in the handheld, and sends them to care providers. Figure 4 shows final decision support screen. Estimated probability of deleterious outcomes and 95% confidence intervals are visualized on the screen.

Expenditures

	3Q FY 00	4Q FY 00	1Q FY 01	2Q FY 01	
Element of Resource (EOR)	Apr 1 - May 31	Jun 1 - Sep 30	Oct 1 - Dec 31	Jan 1 - Mar 31	TOTALS
Travel 2100	0.00	0.00	0.00	0.00	0.00
Shipping 2200	0.00	0.00	0.00	0.00	0.00
Rent & Communications 2200	0.00	0.00	0.00	0.00	0.00
Contract for Services 2500	0.00	0.00	0.00	0.00	0.00
Supplies 2600	0.00	0.00	0.00	0.00	0.00
Equipment 3100	0.00	0.00	0.00	0.00	0.00
GRAND TOTALS	0.00	0.00	0.00	0.00	0.00

Financials

Default stated to be 0.0

Final Results

1) Field test The configured PDA and wireless connection to the server were user-tested by six Emergency physicians, nurses and medics from Tripler Army Medical Center. The

individuals were asked to input fictitious patient data and send it wirelessly to the server. The events observed consisted of 1) ease of use, 2) rapidity of use, 3) any user learning that was required, 4) preferences in use. The test took place outdoors for maximum connectivity. Two units were unable to establish connectivity rapidly. The users found the PDA to be easy to use in its configuration and fields for input. Rapidity of use depended on an individual's prior experience with a PDA. Those familiar with the PDA were rapid in input of patient data and sending it to the server. They were also pleased to receive within seconds, a calculated decision from the server. Those not familiar with the PDA were able to quickly learn (within 5 minutes) the process (although the graffiti feature distracted them and they preferred the keyboard to avoid mistakes). Most individuals preferred the keyboard for inputting patient data. The overall comments about the system were very positive and the individuals agreed that this system could make important contributions to emergency healthcare. 2) Comparison between expert opinion and decision support system for decision making with cross-sectional data Expert opinion Two medical doctors, two nurses and two medics participated to this trial. Following information of these patients was distributed to each responder, which was derived from actual patients with crush injury at the Hanshin-Awaji Earthquake: age, gender, injury site (head, chest abdomen, right arm, left arm, right leg and left leg), time until rescued, respiratory rate, systolic blood pressure, pulse rate, availability of urine and urine color if available. Each responder was asked to roughly estimate the probability of having a deleterious outcome defined as receiving hemodialysis or death. One hundred twenty patient records were selected because they had almost complete information. Each responder was asked to estimate a probability of deleterious outcome (defined above) for each patient. Validation of the prognostic model The remaining 110 cases (test dataset) were used to validate the predictive model. The missing values in this data set were inputted to correctly evaluate the usefulness of this predictive model in a real-world situation. Evaluation of diagnostic accuracy All raw probabilities derived from both the decision support system and experts were used to generate receiver-operating (ROC) curve to evaluate performance. The ROC curve represents the relationship between sensitivity and specificity, by plotting the true-positive rate (sensitivity) against the false-positive rate (1- specificity) as the cutoff level of the model varies. The area under the ROC curve (AUC) is based on a non-parametric statistical sign test to compare the probability of events between pairs of patients who have the event and those who do not. AUC may be interpreted as the probability that given any two subjects, one who dies and one who survives, the model would assign a higher probability of death to the one who dies. It is a measure of overall classification performance of a diagnostic test or prognostic model. Then, all raw probabilities were converted into binary categories. We used 50% of probability as a threshold of possible good and bad outcomes. This means that any estimated probabilities less than 50% were classified as a "good outcome" and that greater than or equal 50% were classified as "deleterious outcome". These results were compared to the actual outcome data in each responder including the computer-based decision support system to calculate sensitivity and specificity. 2) Results ROC curve and AUC Figure 5 shows the ROC curve for responder A to F and the decision support system. Table 2 shows the AUC of each ROC curve. The decision support system showed the best AUC, which is statistically significantly better than coin- flipping decision making with cross sectional data. Sensitivity and Specificity Table 3 shows the overall accuracy, sensitivity and specificity of the decision support system and experts' decision making. As the AUC shows, the overall accuracy of the decision support system is the best of all. Sensitivity and specificity of expert decision making, however, shows some interesting aspects of medical decision making in a triage situation. Specificity by expert B, C and E showed extremely high values compared with the decision support system. It means that these experts tried

to identify very severe patients who required immediate rescue activities (aggressive triage). In contrast, expert D seemed to try to increase sensitivity. This means that the expert tried to identify as many patients as possible to avoid false negatives (conservative triage). Expert A and F showed similar attitudes as the decision support system (neutral triage). This kind of decision totally depends on purpose, situation and location of triage as well as resource availability. Naturally, the computer cannot make such a decision without any input regarding this information. Therefore, these results showed an important difference between computer-based decision making and expert decision making, and roles of computer-based decision support in triage. Computers may be able to provide good results if the care provider can give the system crucial information, such as purpose, situation and location of triage as well as resource availability, (which the computer cannot determine). The results also showed the difficulty of doing triage with cross-sectional data entry (care providers usually make a decision using time sequential information). Therefore, this is an important role of a computer-based decision support system.

Projected Costs

o Current commercial wireless Internet service is not enough for this purpose. We need to use alternative technology to solve this important limitation. o We have identified concrete solutions for this issue during this project and plan to implement these in future projects. Therefore, we cannot calculate the cost at this time.

Comments

o We realized that technologies have been improving rapidly during this project. Some useful technologies that were not available when we submitted the proposal are now extensively applied. o Considering this issue, we were able to try several advanced technologies in telemedicine in order to solve current problems in disaster medicine.

TATRC Scientific Review

TATRC Acquisition Review

Supporting Graphs/Charts

See Attached

Table 3. Sensitivity and specificity

Decision Support System

		Actual Outcome: Good	Actual Outcome: Deliterious	Total
Predicted Outcome	Good	14	7	21
	Deliterious	3	10	13
	Total	17	17	34

Accuracy	70.59%
Sensitivity	58.82%
Specificity	82.35%

Expert A

		Actual Outcome: Good	Actual Outcome: Deliterious	Total
Predicted Outcome	Good	36	21	57
	Deliterious	15	36	51
	Total	51	57	108

Accuracy	66.67%
Sensitivity	63.16%
Specificity	70.59%

Expert B

		Actual Outcome: Good	Actual Outcome: Deliterious	Total
Predicted Outcome	Good	53	45	98
	Deliterious	3	17	20
	Total	56	62	118

Accuracy	59.32%
Sensitivity	27.42%
Specificity	94.64%

Expert C

		Actual Outcome: Good	Actual Outcome: Deliterious	Total
Predicted Outcome	Good	49	53	102
	Deliterious	5	10	15
	Total	54	63	117

Accuracy	50.43%
Sensitivity	15.87%
Specificity	90.74%

Expert D

		Actual Outcome: Good	Actual Outcome: Deliterious	Total
Predicted Outcome	Good	10	8	18
	Deliterious	44	55	99
	Total	54	63	117

Accuracy	55.56%
Sensitivity	87.30%
Specificity	18.52%

Expert E

		Actual Outcome: Good	Actual Outcome: Deliterious	Total
Predicted Outcome	Good	47	45	92
	Deliterious	6	19	25
	Total	53	64	117

Accuracy	56.41%
Sensitivity	29.69%
Specificity	88.68%

Expert F

		Actual Outcome: Good	Actual Outcome: Deliterious	Total
Predicted Outcome	Good	41	23	64
	Deliterious	15	41	56
	Total	56	64	120

Accuracy	68.33%
Sensitivity	64.06%
Specificity	73.21%